Impact of a Foliar Fungicide on Corn Under Induced Drought Stress

Abstract

Since 2007, over 20 percent of the corn (*Zea mays* L.) acres across the Midwest received an in-season foliar fungicide application. Along with protecting plants against fungal pathogens, agrichemical companies claim that fungicides may improve plant tolerance to abiotic stress. The objective of this project was to evaluate the impact of a commercial fungicide (prothioconazole + trifloxystrobin) on corn growth and development in the presence and absence of drought. A greenhouse experiment was conducted from October through December 2015 in Columbus, OH. Pioneer corn hybrid was planted in three gallon, plastic pots, and received one of four fungicide treatments (none, or application at V4, V6 or V4 and V6). Half the plants in each fungicide treatment were exposed to a 15-day drought event beginning at V8. Height, relative chlorophyll content, and leaf stage were measured weekly, and biomass and yield potential was determined at R1 growth stage. Plant biomass was greater in the non-drought plants over the drought plants (109.7 g and 96.6 g, respectively), which may be attributed to a delay in growth caused by the drought event. Fungicide treatment did not influence plant biomass. Yield potential was similar for fungicide treatments, and was greater for plants under drought due to an increased number of kernel rows (prior to V5) rather than a change in kernels per row (determined after V6). The fungicide application did not improve relative chlorophyll content, biomass, or yield potential of plants exposed to the drought event. This study will be repeated in time to validate the observed results.

Introduction

Between 2006 and 2007, the application of foliar fungicides to hybrid corn (*Zea mays* L.) increased dramatically. Since then, over 20 percent of the corn acres across the Midwest get sprayed with a foliar fungicide on an annual basis (Bradley and Ames, 2010). This increase in foliar fungicide applications may have been provoked by many factors including: extremely high commodity prices for corn, an increase in fungicide technology and chemistry to provide better control for diseases, and agrichemical companies marketing and pushing foliar fungicide applications that provide better, overall “plant health” (Bradley and Ames, 2010).

One of the most common biotic stresses to corn is the presence and infestation of foliar diseases. In 2013, it’s estimated that over 1.1 billion bushels of corn across the Corn Belt were lost to disease pressure (Mueller and Wise, 2014). However, fungicides on the market today are able to combat foliar diseases such as northern corn leaf blight (*Exserohilum turcicum*) and gray leaf spot (*Pyricularia grisea*) to help protect yield (Bayer CropScience. 2013; BASF, 2015). When applied, these fungicides not only have preventive attributes to block future disease infections on new plant tissue, but they also have curative properties that can actually fight the diseases that have already infected the plant (Bayer CropScience, 2013; BASF, 2015). An early stage (V4-V7) application at labeled rates can increase yield by 6.8 bushels per acre compared to an untreated control (Bayer CropScience, 2013).

However, providing protection from diseases is not the only marketed use for foliar fungicides. Companies also have cited a positive effect on corn yields during years of high environmental stress by helping protect the plant against moisture deficiency and temperature extremes (Bayer CropScience, 2013; BASF, 2015). One major environmental stress that can severely decrease yield in corn is drought stress. From V8 through V16, the corn plant is actively determining the length of the ear by figuring out how many kernels it can produce in each of one of its already determined rows (Carcova et al., 2003). During this phase, each corn plant is requiring up to 0.31 inches of water per day to maximize growth (Heatherly and Ray, 2007).

In 2012, Ohio corn yields were reduced by 25% compared to yields from 2010 and 2011 (USDA-NASS, 2015). This not only had a severe impact on Ohio's agricultural community but all of the United States as prices for food and other consumer products increased dramatically (USDA-ERS, 2013). If there is an increase in yield potential from foliar fungicides during our simulated drought stress, this could potentially help reduce the negative effects that farmers and consumers feel when there is a water shortage during the corn growing season.

The objective of this research project is to test the claims that are made by many fungicide producing agrichemical companies who state that their fungicide is able to offer tolerance to many environmental stresses. In order to test this claim, this project is going to focus on the response of the corn plant under late vegetative drought stress and how an early-season application of foliar fungicide aids or hinders the corn plant in regards to yield potential.

Methods

This research project was conducted in the Howlett Hall greenhouses at the Ohio State University in Columbus, Ohio and ran from October to early January. We conducted this research using a Pioneer hybrid (P0965YXR), which was selected for the above average ear flex, moderate drought tolerance, and lower stay-green characteristics compared to other hybrids from Pioneer. The corn was grown in three-gallon pots for the duration of their growing period to minimize root

Table 1. Treatment list for experiment.

Treatment	Stage	Drought	Number
1	None	No	4
2	V4 Application	No	4
3	V6 Application	No	4
4	V4 and V6 Application	No	4
5	None	Yes	4
6	V4 Application	Yes	4
7	V6 Application	Yes	4
8	V4 and V6 Application	Yes	4

constriction. MetroMix 830 (Sun Gro Horticulture Canada Ltd., Seba Beach, Alberta, Canada) was used as the growing medium for all 32 pots. The experiment was conducted as a randomized complete block design (four blocks serving as replication) with a full factorial of fungicide application and drought treatment. Treatments include an application of the fungicide Stratego YLD (prothioconazole + trifloxystrobin, Bayer Crop Science, Research Triangle Park, NC) at one or two growth stages (Table 1). All applications were applied using rates of 0.5284 oz. per acre of prothioconazole and 1.571 oz. per acre of trifloxystrobin, which are all labeled rates and timings for early season fungicide applications (Bayer Crop Science, Research Triangle Park, NC). All fungicide applications were applied using the Kottman Hall spray chamber.

Throughout the experiment, weekly measurements were taken that included plant height, growth stage, and SPAD readings. When the corn reached the V8 growth stage, we exposed half the plants from each fungicide treatment to a drought period for 15 days with two 16.9 watering's halfway through the simulated drought. All non-drought treatments were watered as normal by the greenhouse staff. At the end of the drought, the non-drought plants managed, on average, a leaf collar advantage over the drought plants, V12 and V13, respectively. According to the Pioneer Drought Rating Scale, the non-drought treatments achieved a nine rating, while the drought plants achieved a five rating. In order to rehydrate the plants and their growing media after the drought, the pots were vigorously watered and placed in shallow buckets to soak in for a couple of hours.

Once the plants reached the R1 (silk) growth stage, the experiment was terminated. All of the ears were harvested and measured for yield potential along with all above ground biomass. In order to calculate each treatment's yield potential, the number of female floret rows on each ear was counted. Also, the florets per row were also counted. Total yield potential was calculated by taking the number of floret rows and multiplying it by the number of florets per row. From this information, we will be able to assess the yield potential and how it differs from the plants that were sprayed with a foliar fungicide against those that were not. It will also inform us if there is any increase in yield potential from the plants that were put through the drought stress and whether or not the foliar fungicide was able to protect the plant and its yield potential. Dry ear biomass (in grams) was also measured. In order to calculate total above ground biomass, each plant was harvested and placed in brown paper bags in drying oven for approximately two weeks at 70°C. Total biomass was calculated by taking the dry weights of the following: all above ground vegetative growth, tassels, and harvested ears.

All data was analyzed using the mixed procedure in SAS 9.4 (SAS Institute, Cary, NC). Within each sampling date, fungicide application and drought treatment were fixed factors, and block was used as the random factor in the model. When the Global F-test was significant, the means were separated using the PDIFF statement.

Results

Table 2. Total biomass, ear biomass, average number of kernel rows (ROW), average number of kernels per row (KPR), and total kernels per ear (KPE). No significant fungicide effects were observed. Uppercase letters denote differences between drought treatments. Lowercase letters denote differences of the drought by fungicide interaction. Absence of letters denotes non-significance.

Drought Treatment	Fungicide Application	Total Biomass (grams)	Ear Biomass (grams)	ROW	KPR	KPE
No	NONE	114.01A	0.40c	13.5B	39.92	539b
	V4	106.01A	0.92b	14.0B	44.67	625ab
	V6	115.17A	1.70a	15.0B	46.17	693a
	V4 + V6	103.58A	0.38c	13.0B	42.33	550b
Yes	NONE	99.21B	0.54bc	15.0A	43.92	661a
	V4	94.51B	0.58bc	15.0A	46.17	691a
	V6	100.10B	0.54bc	14.5A	43.00	625ab
	V4 + V6	92.60B	0.73bc	15.5A	44.67	693a
Factor		*P*-Value				
Drought		<0.001	0.059	0.009	0.386	0.026
Fungicide Application		0.087	0.007	0.772	0.327	0.363
Drought * Fungicide Interaction		0.941	0.002	0.082	0.309	0.053

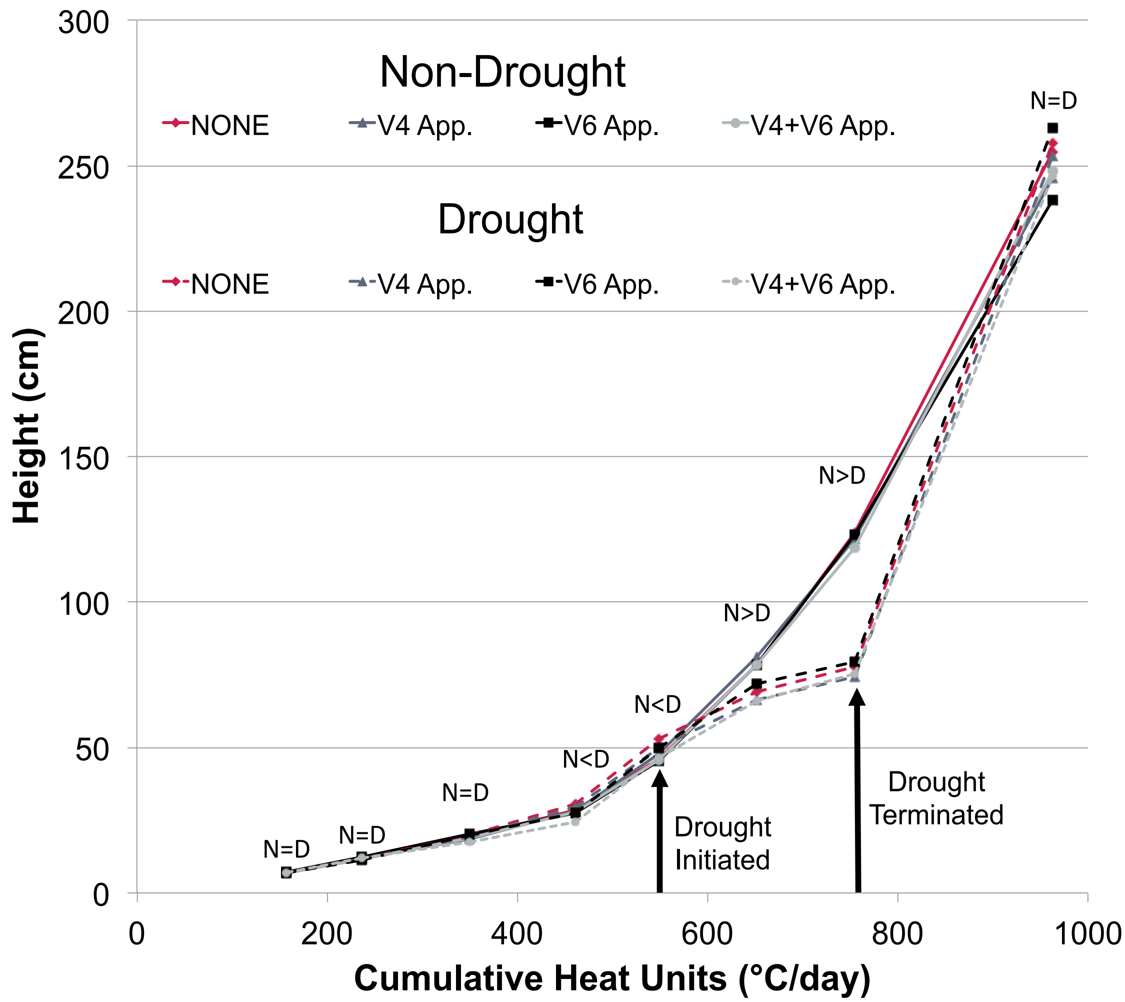

Figure 1. Plant height accumulation from planting to harvest. Significant differences of height for plants within the drought treatments are denoted by sign (α=0.05).

Discussion

When comparing the total yield potential of each our treatments, there was one major difference between the drought and non-drought treatments. The difference was that the drought treatments averaged more than a whole row of female florets more than our non-drought treatments. Because kernel rows are determined before V8, this suggests that the drought treatments were already at an advantage in terms of yield potential before the drought was even initiated. The one potential explanation would be that plants assigned to the drought treatments were significantly taller than the plants assigned to the non-drought treatments even before the drought was initiated, as depicted in Figure 1. This increase in height would have resulted in more sunlight capture and a higher photosynthesis rate than non-drought treatments, which may have resulted in greater potential yield determined early in the growth cycle.

During the drought phase, the non-drought treatments continued their normal growth pattern. However, the drought treatments height tapered off during the drought. Once the drought was terminated, the drought treatments were able to increase their growth in height and recover to the point of no longer being significantly shorter than the non-drought treatments. This rapid height accumulation by the drought plants was probably a response for light competition between the drought and non-drought treatments. However, biomass of the plants exposed to drought was less at R1 compared to the plants that did not experience a drought.

The only growth parameter that had a significant drought x fungicide interaction was the ear biomass parameter (Table 2). A single fungicide application, either at V4 or V6, significantly increased ear biomass of plants in the non-drought treatments only. Under drought conditions, fungicide application did not affect ear biomass.

Conclusions

In conclusion to the research project, the drought treatment effectively reduced plant height during the drought period, but the plants were able to accelerate height accumulation and achieve as similar height as the non-drought plants at R1 harvest. Drought stress reduced total plant biomass and delayed height accumulation, but did not affect kernels per row. Fungicide applications increased ear biomass under non-drought conditions, but did not influence ear biomass under drought. Yield potential was influenced more by early season growth (number of kernel rows) than stage of fungicide application. Based on this research, a fungicide application to protect plants from drought conditions in late vegetative stages is not recommended. However, additional trials should be conducted to validate the observed results.

References

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